

CLAIMS

1. In a data communication network, a method for protecting a node, said method comprising processes of:
- 5 providing a backup bandwidth pool on links of said data communication network;
- identifying a link pair traversing said node, said link pair having a bandwidth to be protected;
- establishing as a backup for said link pair a set of one or more paths that do not include said node and wherein said one or more paths collectively have backup
- 10 bandwidth greater than or equal to said bandwidth to be protected;
- deducting, for each link included in said set of paths, from backup bandwidth available for protecting said node, while not deducting from backup bandwidth available for protecting other nodes in said data communication network; and
- repeating said processes of identifying, establishing, and deducting for a plurality
- 15 of link pairs traversing said node without exceeding available backup bandwidth of links used in establishing said backups.
2. The method of claim 1 wherein said bandwidth to be protected of said link pair comprises a lesser of primary bandwidths of links of said link pair.
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3. The method of claim 1 wherein said bandwidth to be protected of said link pair comprises a total bandwidth of LSPs employing said link pair.

4. The method of claim 1 wherein said set of one or more paths comprises one or more label switched paths.
- 5 5. The method of claim 1 wherein said processes of identifying and establishing occur under control of said node.
6. The method of claim 1 wherein said processes of identifying and establishing occur under control of a computer independent of said node.
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7. The method of claim 1 further comprising:  
signaling said backups to other nodes adjacent to said node in said data communication network.
- 15 8. A method for operating a data communication network to provide protection to nodes in said data communication network, said method comprising:  
maintaining, for each of a plurality of links in said data communication network, a primary bandwidth pool and a backup bandwidth pool; and  
establishing backup tunnels to protect a plurality of nodes of said network, each of
- 20 said backup tunnels consuming backup bandwidth from backup bandwidth pools of selected ones of said plurality of links; and

wherein all backup tunnels protecting any particular node of said network do not consume more bandwidth on any link than provided by the link's backup bandwidth pool but wherein there is at least one set of backup tunnels that protect disparate nodes and

that consume more bandwidth on at least one link than provided by said at least one link's backup bandwidth pool.

5 9. The method of claim 8 wherein at least one of said backup tunnels comprises a label switched path.

10. The method of claim 8 wherein establishing backup tunnels comprises:  
signaling said backup tunnels to adjacent nodes of each protected node.

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11. The method of claim 8 wherein establishing backup tunnels comprises:  
performing backup tunnel selection computations at each protected node for that protected node.

15 12. In a data communication network, apparatus for protecting a node, said apparatus comprising:  
means for establishing a backup bandwidth pool on links of said data communication network;

20 means for identifying a link pair traversing said node, said link pair having a bandwidth to be protected;

means for establishing as a backup for said link pair a set of one or more paths that do not include said node wherein said one or more paths collectively have backup bandwidth greater than or equal to said bandwidth to be protected;

means for deducting, for each link included in said set of paths, from backup bandwidth available for protecting said node while not deducting from backup bandwidth available for protecting other nodes in said data communication network; and

5 means for repeatedly invoking said means for identifying, establishing, and deducting, for a plurality of link pairs connected to said node without exceeding available backup bandwidth of links used in an establishing said backups.

13. The apparatus of claim 12 wherein said bandwidth to be protected of said link pair  
10 comprises a lesser of primary bandwidths of links of said link pair.

14. The apparatus of claim 13 wherein said bandwidth to be protected of said link pair comprises a total bandwidth of LSPs employing said link pair.

15. 15. Apparatus for operating a data communication network to provide protection to nodes of said data communication network, said apparatus comprising:  
means for maintaining, for each of a plurality of links in said data communication network, a primary bandwidth pool and a backup bandwidth pool; and  
means for establishing backup tunnels to protect a plurality of nodes of said network, each of said backup tunnels reserving backup bandwidth from backup bandwidth pools of selected ones of said plurality of links; and  
wherein all backup tunnels protecting any particular node of said network do not consume more bandwidth on any link than provided by the link's backup bandwidth pool but wherein there is at least one set of backup tunnels that protect disparate nodes and

that consume more bandwidth on at least one link than provided by said at least one links backup bandwidth pool.

- 5        16. In a data communication network, a computer program product for protecting a  
node, said computer program product comprising:  
            code that establishes a backup bandwidth pool on links of said data  
communication network;  
            code that identifies a link pair traversing said node, said link pair having a  
10     bandwidth to be protected;  
            code that establishes a backup for said link pair a set of one or more paths that do  
not include said node and wherein one or more paths collectively have backup bandwidth  
greater than or equal to said bandwidth to be protected;  
            code that deducts, for each link included in said set of paths, from backup  
15     bandwidth available for protecting said node, while not deducting from backup  
bandwidth available for protecting other nodes in said data communication network;  
            .  
            code that repeatedly invokes said code that identifies, establishes, and deducts for  
a plurality of link pairs connected to said node without exceeding available backup  
bandwidth of links used in establishing said backups; and  
20     a computer-readable storage medium that stores the codes.

17. The computer program product of claim 16 wherein said bandwidth to be  
protected of said link pair comprises a lesser of primary bandwidths of links of said link  
pair.

18. The computer program product of claim 16 wherein said bandwidth to be  
protected of said link pair comprises a total bandwidth of LSPs employing said link pair.

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19. The computer program product of claim 16 wherein said set of one or more paths  
comprises one or more label switched paths.

20. The computer program product of claim 16 further comprising:

10 code that signals said backups to other nodes adjacent to said node in said data  
communication network.

21. A computer program product for operating a data communication network to  
provide protection to nodes in the data communication network, said computer program  
15 product comprising:

code that maintains, for each of a plurality of links in said data communication  
network a primary bandwidth pool and a backup bandwidth pool; and

code that establishes backup tunnels to protect a plurality of nodes of said  
network, each of said backup tunnels reserving backup bandwidth from backup

20 bandwidth pools of selected ones of said plurality of links;

wherein all backup tunnels protecting any particular node of said network do not  
consume more bandwidth on any link than provided by the link's backup bandwidth pool  
but wherein there is at least one set of backup tunnels that protect disparate nodes and

that consume more bandwidth on at least one link than provided by said at least one link's backup bandwidth pool; and  
a computer-readable storage medium that stores the codes.

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22. The computer program product of claim 21 where at least one of said backup tunnels comprises a label switched path.

23. The computer program product of claim 21 wherein said code that establishes

10 backup tunnels comprises:

code that signals said backup tunnels to adjacent nodes of each protected node.

24. The computer program product of claim 21 wherein said code that establishes  
backup tunnels comprises:

15 code that performs backup tunnels selection computation at each protected node  
for that protected node.

25. A network device for implementing a node in a data communication network, said  
network device comprising:

20 a processor; and

a memory storing instruction for said processor, said instructions comprising:

code that establishes a backup bandwidth pool on links of said data  
communication network;

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- code that identifies a link pair traversing said node, said link pair having a bandwidth to be protected;
- code that establishes a backup for said link pair a set of one or more paths
- 5 that do not include said node and wherein one or more paths collectively have backup bandwidth greater than or equal to said bandwidth to be protected;
- code that deducts, for each link included in said set of paths, from backup bandwidth available for protecting said node, while not deducting from backup bandwidth available for protecting other nodes in said data communication network; and
- 10 code that repeatedly invokes said code that identifies, establishes, and deducts for a plurality of link pairs connected to said node without exceeding available backup bandwidth of links used in establishing said backups.

26. The network device of claim 25 wherein said bandwidth to be protected of said  
15 link pair comprises a lesser of primary bandwidths of links of said link pair.

27. The network device of claim 25 wherein said bandwidth to be protected of said link pair comprises a total bandwidth of LSPs employing said link pair.

20 28. The network device of claim 25 wherein said set of one or more paths comprises one or more label switched paths.

29. The network device of claim 25 wherein said instructions further comprise:

code that signals said backups to other nodes adjacent to said node in said data communication network.

5 30. A network device for implementing a node in a communication network, said network device comprising:

a processor; and

a memory storing instruction for said processor, said instructions comprising:

code that establishes backup tunnels to protect a plurality of nodes of said

10 network, each of said backup tunnels reserving backup bandwidth from backup bandwidth pools of selected ones of said plurality of links;

wherein all backup tunnels protecting any particular node of said network do not consume more bandwidth on any link than provided by the link's backup bandwidth pool but wherein there is at least one set of backup tunnels that protect  
15 disparate nodes and that consume more bandwidth on at least one link than provided by said at least one link's backup bandwidth pool.

31. The network device of claim 30 where at least one of said backup tunnels comprises a label switched path.

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32. The network device of claim 30 wherein said code that establishes backup tunnels comprises:

code that signals said backup tunnels to adjacent nodes of each protected node.

33. A method for protecting a node in a data communication network, said method comprising:  
performing computations at said node to identify backup tunnels to protect said  
5 node; and  
signaling said backup tunnels to other nodes of said data communication network.
34. Apparatus for protecting a node in a data communication network, said apparatus comprising:  
10 means for performing computations at said node to identify backup tunnels to protect said node; and  
means for signaling said backup tunnels to other nodes of said data communication network.
- 15 35. A computer program product for protecting a node in a data communication network, said computer program product comprising:  
code that performs computations at said node to identify backup tunnels to protect  
said node;  
code that signals said backup tunnels to other nodes of said data communication  
20 network; and  
a computer-readable storage medium that stores the codes.

36. A network device that implements a node in a data communication network, said network device comprising:

a processor;  
a memory device storing instructions for said processor, said instructions comprising:  
5 code that performs computations at said node to identify backup tunnels to protect said node; and  
code that signals said backup tunnels to other nodes of said data communication network.

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